REMARKS

Claims 2-9 and 11-17 remain in this application. Claims 1 and 10 have been cancelled and new claims 15-17 have been added. Claims 2, 5, 11 and 12 have been amended to better define Applicants invention. Claim 14 has been amended to overcome the Examiner's rejection based on 35 U.S.C.§112.

The Claims

The subject matter to which the various claims are directed is as follows:

(1) Claims 2 to 4, 11, and 14

These claims are directed to a perpendicular magnetic recording medium having a substrate, a soft magnetic underlayer, a non-magnetic amorphous metal layer, and a perpendicular recording layer laminated in this order. The perpendicular magnetic recording medium is characterized in that "the non-magnetic amorphous metal layer contains Ni" and "the non-magnetic metal layer has a thickness of 2 to 10 nm."

The above features enable the reduction of medium noise attributable to the perpendicular recording layer, thereby realizing a perpendicular magnetic recording medium having a high recording density and high reliability.

(2) Claims 5 to 9, 12, and 13

These claims are directed to a perpendicular magnetic recording medium having a substrate, a soft magnetic underlayer, a non-magnetic intermediate layer, and a perpendicular recording layer laminated in that order. The perpendicular magnetic recording medium is mainly characterized in that "the soft magnetic underlayer contains α-Fe nano-crystals" and "the soft magnetic underlayer is formed as an amorphous film by sputtering and formed as an α-Fe nano-crystalline film by heat treatment."

The above features enable the reduction of medium noise attributable to the soft magnetic layer, thereby realizing a perpendicular magnetic recording medium having a high recording density and high reliability.

(3) Claims 15 to 17

These claims are directed a perpendicular magnetic recording medium having a substrate, a soft magnetic-underlayer, a non-magnetic amorphous metal layer, and a perpendicular recording layer laminated in this order. The perpendicular magnetic recording medium is mainly characterized in that "the soft magnetic underlayer contains α-Fe nano-crystals," "the non-magnetic amorphous metal layer contains Ni," and "the soft magnetic underlayer is formed as an amorphous film by sputtering and formed as an α-Fe nano-crystalline film by heat treatment."

The above features enable the reduction of medium noises attributable to the perpendicular recording layer and the soft magnetic layer, thereby realizing a perpendicular magnetic recording medium having a high recording density and high reliability.

Teaching of Cited References

Chen et al. discloses a medium having an amorphous layer of NiNb arranged between a substrate and a magnetic layer (recording layer). The amorphous NiNb layer can be applied to a longitudinal recording medium or to a perpendicular recording medium. However, the amorphous NiNb layer of Chen et al. is provided with the aim of obtaining an effect of a scaling layer that prevents Li contained in a glass substrate from migrating into a film. Therefore, the film thickness is from 10 to 100 nm, which is rather thick. In contrast, the Ni amorphous intermediate layer of the present invention is arranged between the soft magnetic underlayer and the perpendicular recording layer, and has the effects of changing the c-axis of a Co alloy layer to vertical orientation and breaking a magnetic coupling between the recording layer and the soft magnetic underlayer. The Ni amorphous intermediate layer typically has a film thickness of 5 nm, which is rather thin.

Further, Chen et al. teaches that the amorphous NiNb layer can be applied to a longitudinal recording medium or a perpendicular recording medium, but their specification describes effects and examples of the amorphous NiNb layer only when it is applied to a longitudinal recording medium. The specification does not describe specific effects of the amorphous NiNb layer when it is applied to a perpendicular medium, or examples regarding a

perpendicular medium. That is, the effect of the amorphous NiNb layer that is disclosed in Chen et al., when it is applied to a perpendicular recording medium is only the prevention of Li migration as mentioned above.

Hokkyo et al. discloses that FeAlSi or FeTaN formed as a soft magnetic underlayer by sputtering in Ar gas with the substrate temperature at 400°C at the time of forming a perpendicular recording layer. According to the present invention, an FeTaN film is formed by sputtering an FeTa alloy target in an Ar/N_2 mixed gas, and the FeTaN film is amorphous at the time of film formation and treated by heat to have a microstructure wherein α-Fe nano-crystals are precipitated in a three-dimensionally random order. In contrast, the FeTaN film of Hokkyo et al. is formed by sputtering in Ar gas, though a target composition therefor is not disclosed (since the sputtering gas does not contain N_2, it is presumed that a FeTaN alloy is used as a target).

Comparison between the claims and the teaching of cited references

(1) Chen et al.

Chen et al. dose not disclose or suggest that the film thickness of the non-magnetic metal layer is made to be thinner, or more specifically that the layer is formed in a film thickness of 2 to 10 nm.

(2) Hokkyo et al.

Hokkyo et al. does not disclose or suggest that the soft magnetic underlayer is formed as an amorphous film by sputtering and then is formed into an α-Fe nano-crystalline film by heat treatment.

The examiner presumed that the FeTaN film is substantially the same as the soft magnetic underlayer of the present invention. However, Applicants do not agree with this presumption for the following reasons.

Hokkyo et al. does not disclose a microstructure at the time of forming the FeTaN film or after the heat treatment. Further, it does not disclose variations of soft magnetic properties of the

FeTaN film between before and after the heat treatment. Therefore, the heat treatment is carried out for controlling the film formation temperature of a perpendicular recording layer, and presumably this process does not have an aim of enhancing the soft magnetic properties of the FeTaN film.

According to the analysis of the present inventors (refer to Embodiment 4), when a FeTaN sputter film is used as a soft magnetic underlayer, α-Fe may have different structures depending on alloy compositions used for target and film formation processes using, for example, a sputter gas. In one case, the α-Fe is crystallized at the time of film formation and has a columnar polycrystalline structure. In the other case, the α-Fe is amorphous at the time of film formation, and then treated by heat, thereby having a microstructure wherein α-Fe nano-crystals are precipitated in a three-dimensionally random order. It is found that the noise attributable to the soft magnetic underlayer can be reduced only in the latter case. On the other hand, Hokkyo et al. refers only to the surface smoothness of the soft magnetic underlayer, and does not describe the effects of a nano-crystal structure.

As described above, the use of a FeTaN film as a material for the soft magnetic underlayer is insufficient to attain the feature of the present invention, that is, the reduction of noise attributable to the soft magnetic underlayer. Thus, it is necessary to have a microstructure wherein α-Fe nano-crystals are precipitated in a three-dimensionally random order. One cannot derive these points by analogy from Hokkyo et al.

The Examiner has combined additional references to reject various dependent claims. However, aside from questions of the propriety of combining these references with the two basic references, Applicants note that none of them makes up for the deficiencies in the teachings teaching of Chen et al. and Hokkyo et al. All of the claims include the limitations missing from the two basic references and for that reason distinguish over the art.

In view of the above, this application is now in condition for allowance, prompt notice of which is respectfully solicited.

The Examiner is invited to call the undersigned at (202) 220-4200 to discuss any information concerning this application.

Applicants respectfully request a one month Extension of Time to respond to the Office Action of May 12, 2003. The extended period expires September 12, 2003.

The Office is hereby authorized to charge the fee of $110.00 for a Petition for Extension of Time Under 37 C.F.R. § 1.136(a) and any additional fees under 37 C.F.R. § 1.16 or § 1.17 or credit any overpayment to Deposit Account No. 11-0600.

Respectfully submitted,

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John C. Altmiller
Registration No. 25,951

KENYON & KENYON
1500 K Street, N.W., Suite 700
Washington, D.C. 20005
Tel.: (202) 220-4200
Fax.: (202) 220-4201
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